30th Annual AIAA/USU Conference on Small Satellites
Logan, UT
August 6-11, 2016

CubeSat Space Environments Effects Studied in the Space Survivability Test Chamber

JR Dennison, Gregory Wilson, Alex Souvall,
Ben Russon, and Katie Gamaunt

Materials Physics Group, Physics Department, Utah State University

Abstract

CubeSats are particularly susceptible to environmental-induced modifications, which can lead to deleterious or catastrophic consequences. This is increasingly important as small satellites—with minimal shielding due to reduced mass and size constraints and reliance on more compact and sensitive electronics—have longer mission lifetimes and make more diverse, complex and sensitive measurements. The current push to expand deployment of CubeSats beyond LEO, into even more demanding environments where modest relief due to shielding by the Earth's magnetosphere is absent (such as polar or GEO orbits), can further exacerbate these problems.

Testing of small satellites is therefore critical to avoid such problems. A new versatile Space Survivability Test chamber for ground-based accelerated testing of space environment effects is well-suited for cost-effective, long-duration testing of complete systems up to the size of a 1U CubeSat (<20 cm dia.), smaller components or electronics, and individual material samples. The facility simulates critical space environment conditions: these include neutral gas atmospheres and vacuum ($<10^{-5}$ Pa) and thermal cycling (~100 K to >450 K), as well as ionizing radiation, electron plasma (<10 eV to ~30 keV), and vacuum ultraviolet through mid-infrared photon fluxes with <5% uniformity over the area of a CubeSat face at intensities for ~4-10X accelerated testing. A Sr^{90} β-radiation source produces a high-energy (~200 keV to >2½ MeV) spectrum similar to the GEO spectrum for testing of radiation damage, single event interrupts, and (often untested off-the-shelf) COTS parts. An automated data acquisition system periodically monitors and records the real-time environmental conditions—along with *in situ* monitoring of key satellite/component/sample performance metrics together with characterization of material properties and calibration standards—during the sample exposure cycle. Multiple *in-flux* or *in-situ* space survivability and radiation exposure tests can be performed simultaneously, which complement extensive before and after *ex-situ* tests.

Such measurements for 1U CubeSats and typical components serve to forecast sample radiation damage, predict lifetimes of electronics, and substantiate the ability of the chamber to mimic space environments. Results of specific tests of the effects due to UV and ionizing β-radiation are presented, which include: modified efficiency of flexible solar arrays; single event upsets and radiation-induced failure of COTS microcontrollers, memory, and sensors; structural damage and modifications of mechanical and electrical properties; changes in electron transport and arcing of materials; and modification of optical darken and transmission/reflectivity properties and related color center generation of glasses and polymeric materials. Comparative studies of SST ground-based tests to tests of space-flown samples are used to gauge the ability of the chamber to mimic the space environment and predict space radiation damage effects.

Paper Number: SSC16-